



March 3<sup>rd</sup>, 2011

Marlene H. Dortch  
Secretary  
Federal Communications Commission  
445 12<sup>th</sup> Street, S.W.  
Washington, DC 20554

In Re: File Number SAT-MOD-20101118-00239  
*Ex Parte* presentation

Dear Ms. Dortch:

On Thursday, March 3<sup>rd</sup>, Chuck Powers, Stu Overby, Greg Buchwald and Bruce Oberlies, all from Motorola Solutions, Inc, met with Julius Knapp, Michael Ha, Walter Johnson, Brian Butler, Brett Greenwalt and Mark Settle, of the Office of Engineering and Technology; Tom Peters and Paul Murray of the Wireless Telecommunications Bureau; and Darryl Smith, Bill Lane and Pat Amodio of the Public Safety and Homeland Security Bureau.

The topic of the meeting was the results of testing that Motorola Solutions performed to assess the potential for interference to GPS receivers in terrestrial base stations and mobile devices that might be encountered through the operation of terrestrial broadband network equipment on Lightsquared's mobile satellite frequencies. The attached material, presented during the meeting, reviews the equipment setup used, and results obtained from this testing.

Respectfully Submitted,

/s/ Chuck Powers

Chuck Powers  
Director, Engineering and Technology Policy  
Global Government Affairs  
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CC: (via email)

Michael Ha	Walter Johnson	Brian Butler
Brett Greenwalt	Mark Settle	Tom Peters
Paul Murray	Darryl Smith	Bill Lane
Pat Amodio	Julius Knapp, Chief, OET	
Jeff Carlisle (Lightsquared)		



# MOTOROLA SOLUTIONS

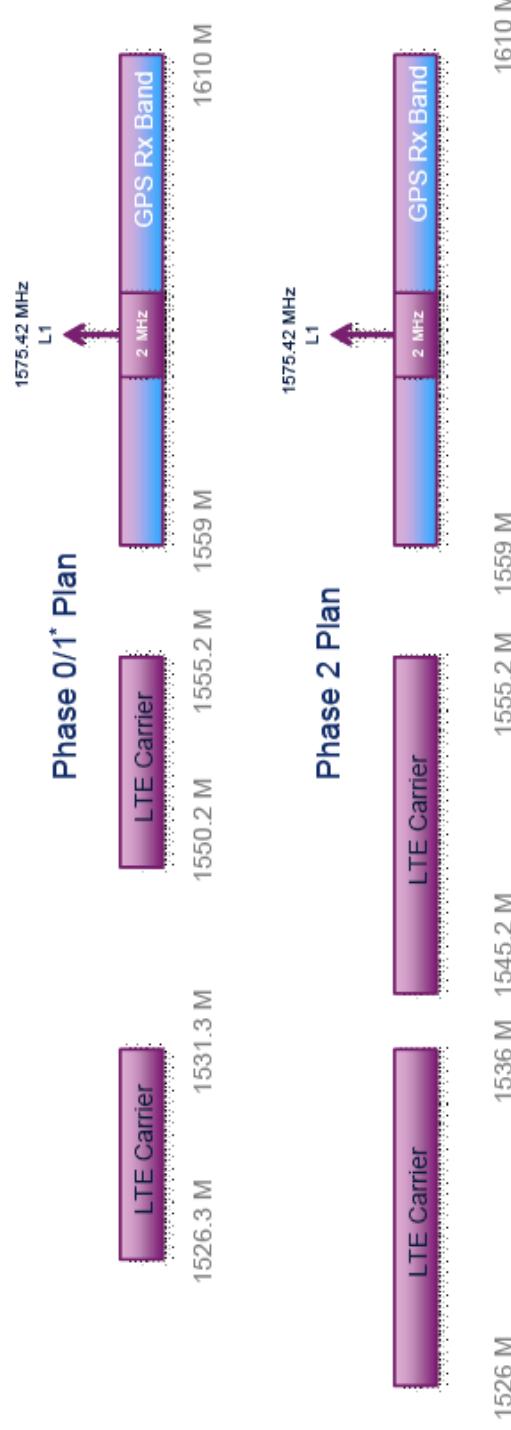
## LightSquared – GPS Interference

# LightSquared Terrestrial Service



## 2.1. L-band ATC Frequency Plans GPS

Figure 1 describes the LightSquared's present ATC frequency plans by deployment phase. These plans are subject to coordination with other satellite operators and may change in the future. However, a change in the frequency plans would not change LightSquared's obligations to protect other services in adjacent bands, such as GPS.



\*Only upper 5-MHz LTE carrier is used in Phase-0. Both 5-MHz carriers are used in Phase-1

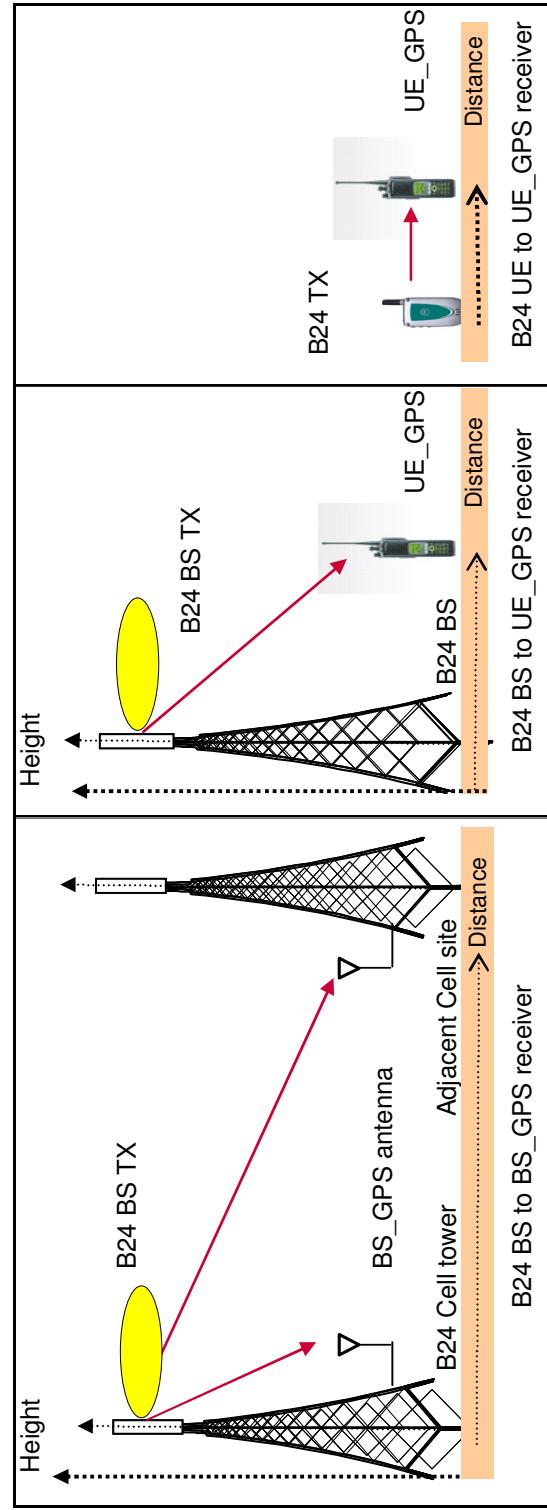
Figure 1: Lightsquared Downlink LTE L-Band and GPS Band

# Interference Scenarios

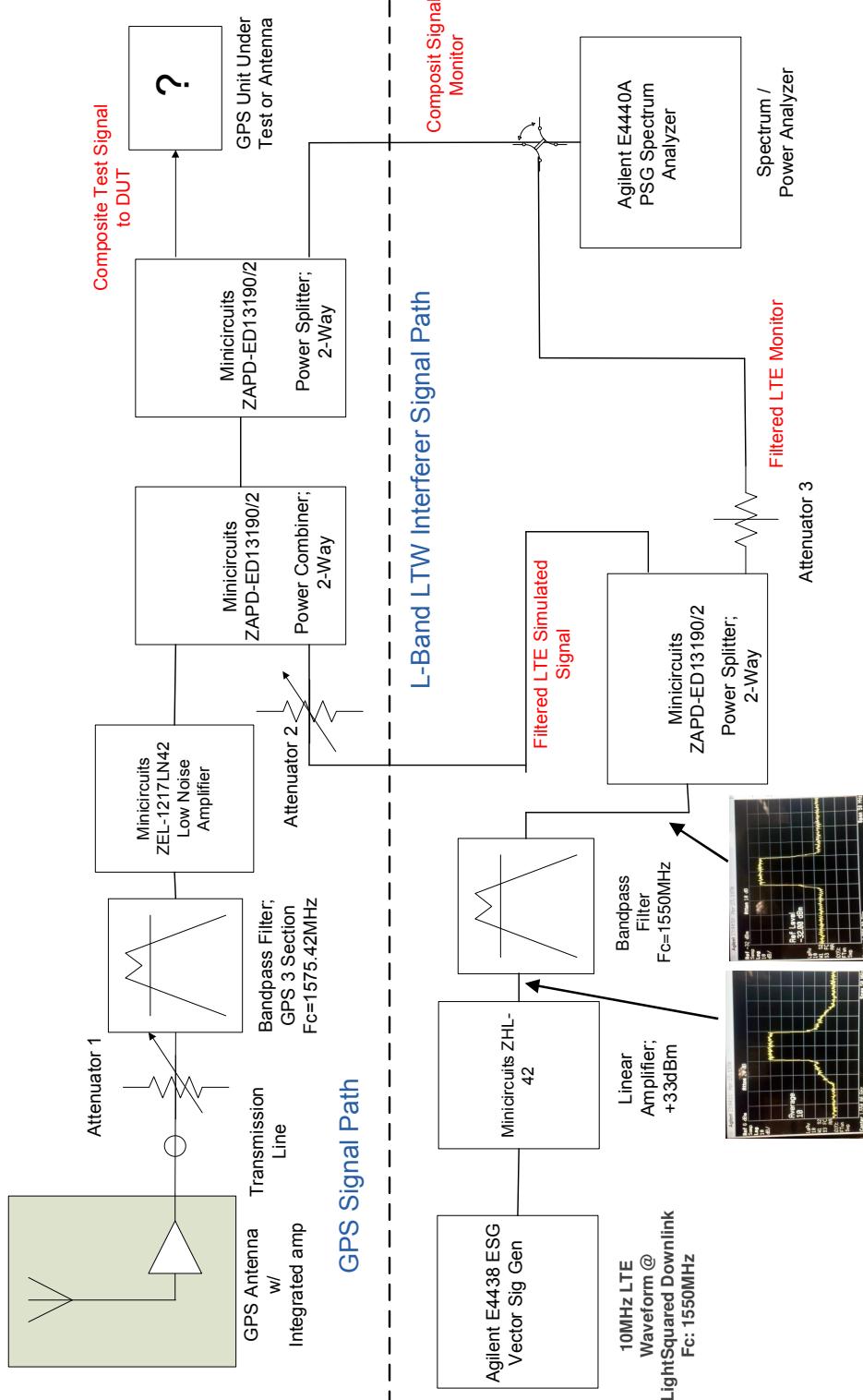


## Two Interference Mechanisms

- 1) OOB-E into GPS receiver – can only be fixed at L.S. transmitter
  - LightSquared is adding filtering to mitigate
- 2) GPS receiver blocking – can only be fixed at receiver
  - Function of GPS receiver design and,
  - Distance between LightSquared Transmitter and Victim Receiver
  - **Cross-Modulation Product-caused Interference.**

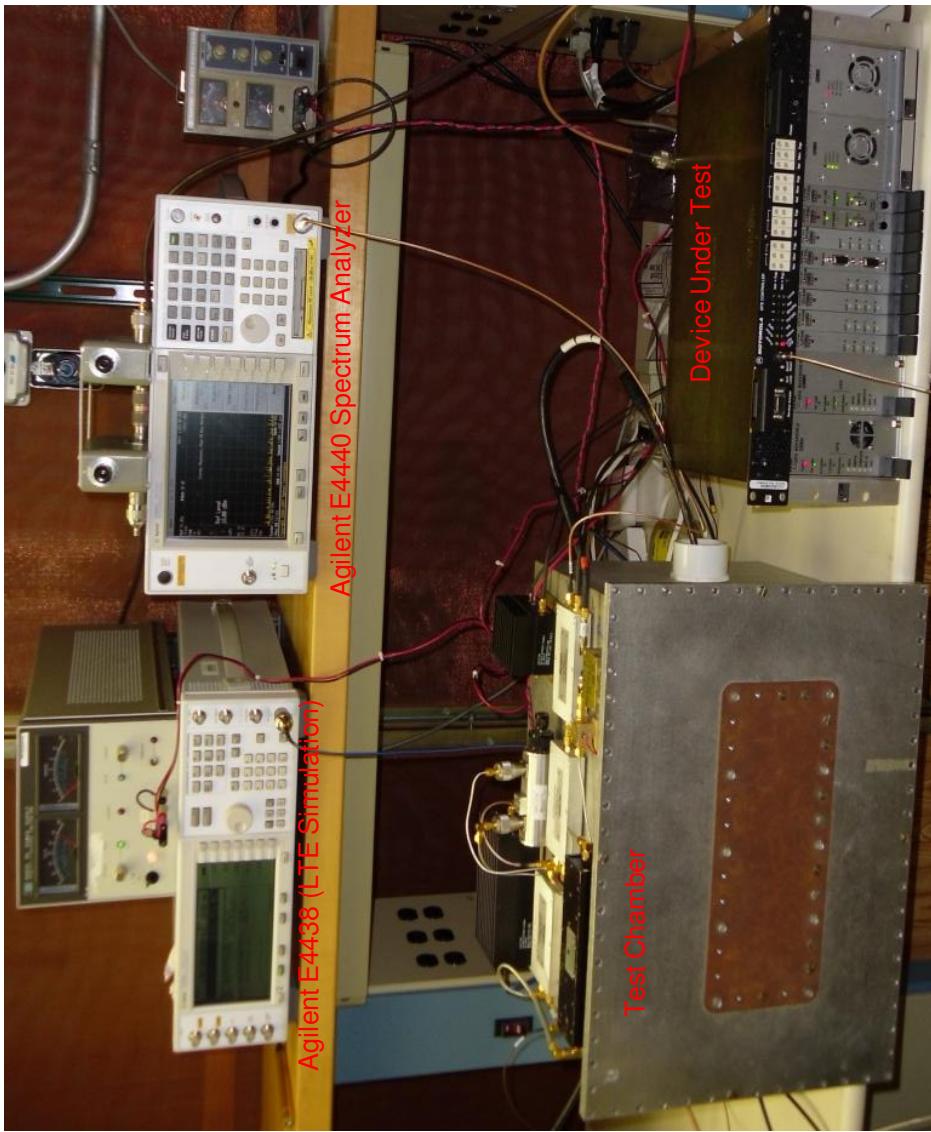
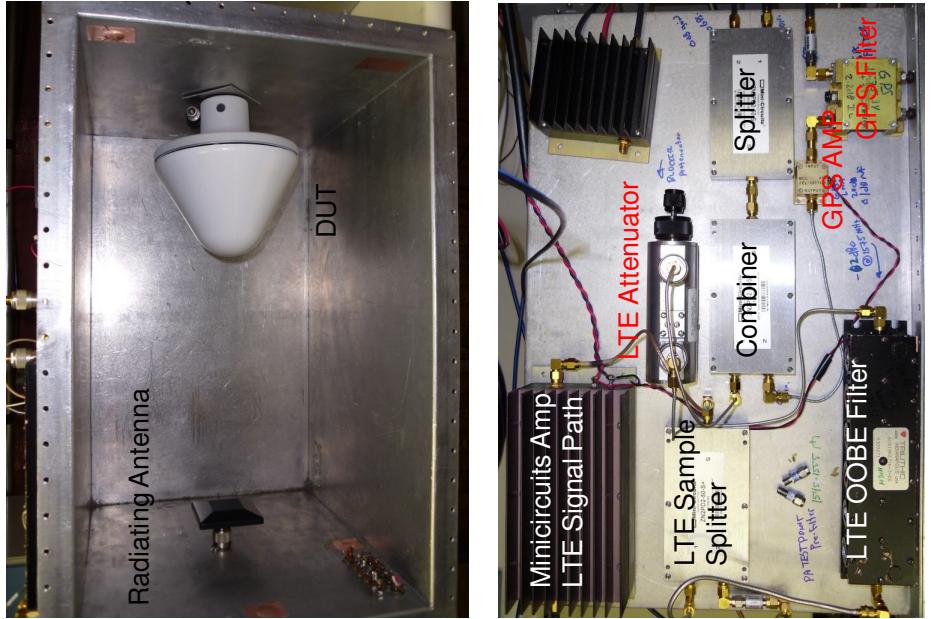


# Laboratory Test Configuration



**Lab Test Configuration**  
**GPS Interference / Blocking Susceptibility to**  
**LightSquared L-Band Transmissions**

# L-Band Interference Test Fixture



# Test Procedure

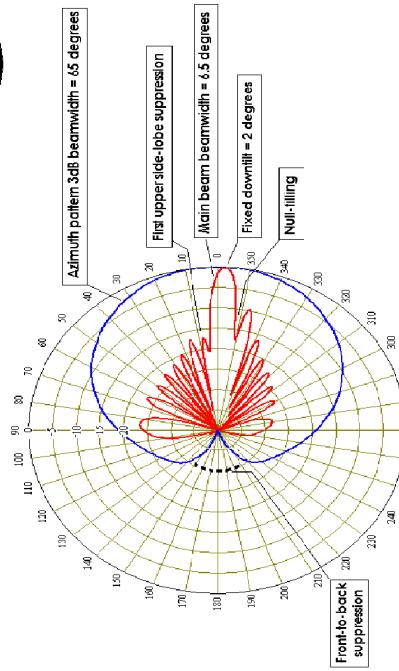


- Determine proper GPS level: -142dBm/2MHz at the receiver / DUT input.
- Increase interfering LTE signal until lock is lost. Reduce interferer level until lock is regained.
- Increase the interferer level by 10dB so that lock is lost.
- Reduce interferer level by 10dB; check receiver / DUT for reception and lock of at least 4 satellites within 60 seconds.
  - If lock is attained, record level.
  - If lock could not be attained, reduce interferer level by 1dB; recheck lock status.
  - Determines level at which the DUT recovers from a short term 10dB increase in interference level
- A total of four measurements were made within a time span of 10 minutes to determine the maximum allowable interference level.
  - The worst case number was thrown out and the remaining 3 levels were retained.
- Repeat at 4, 8, and 16 hour intervals after the initial measurement.
  - Conducted tests: composite test signal is fed directly to the DUT.
  - Radiated tests: path loss between the passive, radiating antenna and the DUT antenna is measured.
- The above-listed tests are performed with a 10MHz BW LTE waveform ( $f_c=1550\text{MHz}$ ).
- Calculate Denial of GPS Service Radius based on Free-space Path Loss (PLE = 2)
  - Denial of GPS Service radius based on 1kW EIRP (+60dBm)

# Interference Distance Calculations

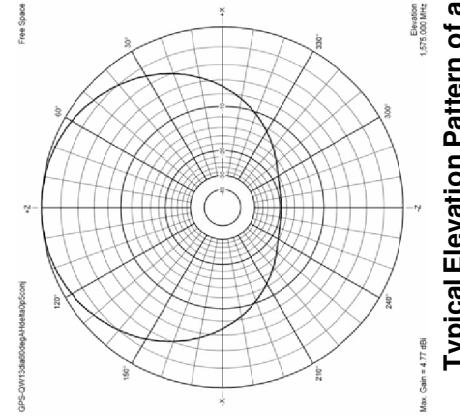


- Freespace Path Loss, FSPL is defined as:
  - $FSPL_{(dB)} = 20\log(d) + 20\log(f_{MHz}) - 27.55$ ; where d is in meters
  - $FSPL_{(dB)} = 20\log(d) + 36.25 @ 1550MHz$
- “Distance A” represents the LOS (Line of Sight) Denial of GPS Service radius assuming FSPL (Path Loss Exponent, PLE=2)
- “Distance B” represents the LOS Denial of GPS Service radius assuming an additional 20dB path loss (PLE=2) due to the elevation pattern of the L-Band base station antenna as well as the elevation pattern of GPS antenna
  - Pattern loss can vary from <12dB to >25dB depending upon deployment; 20dB is a typical value.
- Non-LOS path loss will be higher (ex: Base station to subscriber unit) in many instances. The PLE can vary from <2.8 to >3.6 for concerned range of separation distance.
  - Example: A PLE of 3.3 will reduce the denial of service radius from 3600 meters to 145 meters
  - However, many services and deployment scenarios will endure LOS interference conditions



Single Column Antenna Patterns (dB) vs Angle (deg)  
Elevation Pattern (red trace) Azimuth Pattern (blue trace)

## PCS Antenna Pattern Example



Typical Elevation Pattern of a Quadrifilar GPS Antenna

# Motorola Solutions Infrastructure Results



- Motorola Solutions has completed initial testing of available products
- Lab testing Base Transmit to Base GPS Receive
  - Calculated free space interference radius (A) and most likely (B)

**Test Results: GPS @ -142dBm/2MHz LTE Terrestrial L-band Signal**

Device Under Test	LTE Level; RX Input	Distance A; Bore-sight	Distance B; -20dB
Trak Receiver; Conducted Test	-18 dBm	120 meters	12 meters
Trak Receiver w/ External GPS Antenna / Standard LNA; Radiated Test	-47dBm	3800 meters	380 meters
Trak Receiver w/External GPS Standard Antenna / LNA + 16dB Line Loss; Radiated Test	-35dBm	850 meters	85 meters
Integrated Site Controller; Harmony Model X516; Conducted Test	-20dBm	155 meters	16 meters
GTR Site Controller / GPS Reference w/External GPS RX in Head; Radiated Test	-22dBm	190 meters	19 meters

## Potential Mitigation Methods

- Replace External Antenna / LNA equipment with high OOB/E rejection SAW filters (added filters)
  - Downside: Additional Noise Figure; loss of RX Sensitivity
  - Adjust attenuation between Antenna / LNA and victim receiver
  - Add additional filtering between Antenna / LNA and receiver
  - Judicious physical placement of antenna at base station site.

Downside: Site Visit Necessary; Equipment Purchase; Equipment Procurement and Qualification Process

# Motorola Solutions Subscriber Results



Motorola Solutions has completed initial testing of available products

- Lab testing Base Transmit to Subscriber GPS Receive
- Calculated free space interference radius (A) and most likely (B)

Test Results: GPS @ -142dBm/2MHz LTE Terrestrial L-band Signal

Device Under Test	LTE Level; RX Input	Distance A; Bore-sight	Distance B; -20dB
Gen 2006 PS GPS Microphone Accessory, LightSquared BPF @ 1550MHz Radiated w/GPS -142dBm	-36dBm	1000 meters	100 meters
Gen 2007 Professional / Commercial Radio HH; LightSquared BPF @ 1550MHz; Radiated w/GPS -142dBm	-37dBm	1100 meters	110 meters
Gen 2009 PS HH; LightSquared BPF @ 1550MHz; Radiated w/GPS -142dBm	-35dBm	850 meters	85 meters
Gen 2010 PS HH; LightSquared BPF @ 1550MHz; Radiated w/GPS -142dBm	-22dBm	190 meters	19 meters

## Potential Mitigation Methods

- Redesign device to utilize newer GPS chipset, or
- Re-design the antenna to incorporate a narrowband filter along with the LNA
  - Impact to sensitivity of GPS receiver due to additional insertion loss Reduces, but does not eliminate, the subscriber denial of service radius.



# Primary Consequences of Interference

- Base Station
  - Simulcast Systems
    - Immediate alarm sent to dispatch or control office if tracked and locked satellites drops below 4
    - In as little as 4 hours or as much as 24 hours, site becomes disabled; taken off-line (lack of timing reference)
  - Other systems (iDEN / Harmony, Canopy, Orthogon, etc.)
    - Lost timing accuracy
      - Alarm, system degradation, potential site deactivation
      - Collision avoidance, spectrum efficiency impacts
- Subscriber Units
  - Disillusion of location accuracy
- Officer Scenarios
  - Officer-down location: potential response time impact, etc.
    - Traffic stop location: important in escalated situation
  - Potential impact to location stamping of voice and video recording used for evidence

# Summary

- Early stage testing focus has been on Public Safety; still collecting data on Enterprise
  - No UE to Subscriber testing yet performed
- Currently evaluating antenna solutions to mitigate interference to base GPS receivers
- Field tests are required to confirm real-world susceptibility to interference
- Mitigation means and methods still in development

